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THE USE OF CHEMICALS TO CONTROL FIELD RODENTS AND OTHER PREDATORS. AGRICULTURAL CHEMICALS TECHNOLOGY, NUMBER 5.
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THE PURPOSE OF THIS GUIDE IS TO ASSIST TEACHERS IN PREPARING POST-SECONDARY STUDENTS FOR AGRICULTURAL CHEMICAL OCCUPATIONS. IT IS ONE OF A SERIES OF MODULES DEVELOPED BY A NATIONAL TASK FORCE ON THE BASIS OF DATA FROM STATE STUDIES. SECTIONS ARE (1) USE OF CHEMICALS FOR RODENT CONTROL AND ERADICATION, (2) TERMINOLOGY AND COMPUTATIONS, (3) RODENT IDENTIFICATION, (4) RODENTICIDES, (5) RODENT CONTROL PRINCIPLES AND CONCEPTS, AND (6) CHEMICAL HANDLING, TRANSPORTATION, AND STORAGE. IN ADDITION TO SUGGESTIONS FOR INTRODUCING THE MODULE, THE GUIDE INCLUDES OBJECTIVES, SUBJECT MATTER CONTENT, SUGGESTED TEACHING-LEARNING ACTIVITIES, AND INSTRUCTIONAL AIDS AND REFERENCES FOR EACH SECTION. TEACHERS SHOULD HAVE A BACKGROUND IN AGRICULTURAL CHEMICALS. STUDENTS SHOULD HAVE POST-HIGH SCHOOL STATUS, AN APTITUDE IN CHEMISTRY, AND AN OCCUPATIONAL GOAL IN THE INDUSTRY. THE MATERIAL IS DESIGNED FOR 12 HOURS OF CLASS INSTRUCTION, 36 HOURS OF LABORATORY EXPERIENCE, AND 60 HOURS OF OCCUPATIONAL EXPERIENCE. THIS DOCUMENT IS AVAILABLE FOR A LIMITED PERIOD FOR $6.75 PER SET (VT 001 214 - 001 222) FROM THE CENTER FOR VOCATIONAL AND TECHNICAL EDUCATION, THE OHIO STATE UNIVERSITY, 980 KINNEAR ROAD, COLUMBUS, OHIO 43212. (JM)

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THE USE OF CHEMICALS TO CONTROL FIELD RODENTS AND OTHER PREDATORS

AGRICULTURAL CHEMICALS TECHNOLOGY
No. 5

The Center for Research and Leadership Development
in Vocational and Technical Education

The Ohio State University
980 Kinnear Road
Columbus, Ohio 43212

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M E M O R A N D U M

TO: The ERIC Clearinghouse on Vocational and Technical Education
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FROM: (Person) James W. Hensel (Agency) The Center for Vocational and Technical Education

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DATE: August 7, 1967

RE: (Author, Title, Publisher, Date) Module No. 5, "The Use of Chemicals to Control Field Rodents and Other Predators," The Center for Vocational and Technical Education, December, 1965.

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Uses of Material Instructor course planning
Users of Material Teachers

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Necessary x
Desirable
(Check Which)

Describe Suggested references given in module. (P)

Source (agency)
(address)

This publication is a portion of the course material written in Agricultural Chemicals Technology. To be understood fully, the complete set of materials should be considered in context. It is recommended that the following order be observed for a logical teaching sequence:

#1 - The Use of Chemicals as Fertilizers

#2 - The Use of Chemicals as Insecticides - Plants

#3 - The Use of Chemicals as Soil Additives

#4 - The Use of Chemicals as Fungicides, Bactericides and Nematocides

#5 - The Use of Chemicals to Control Field Rodents and Other Predators

#6 - The Use of Chemicals as Herbicides

#7 - The Use of Chemicals in the Field of Farm Animal Health (Nutrition, Entomology, Pathology)

#8 - The Use of Chemicals as Plant Regulators

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III. To develop the ability to recognize and identify field rodents and similar pests which attack agricultural crops. 13

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V. To gain a knowledge and understanding of the principles and concepts underlying the use of chemicals needed to control field rodents and similar predators. 20

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THE USE OF CHEMICALS TO CONTROL FIELD RODENTS AND OTHER PREDATORS

Major Teaching Objective

To develop skills, abilities, and understanding needed for entry and advancement by technicians in occupational work that pertains to chemical control of field rodents and other predators.

Suggested Time Allotment

At School		
Class Instruction	12 hours	
Laboratory Experience	36 hours	
Total at School		48 hours
Occupational Experience		60 hours
Total for Course		108 hours

Suggestions for Introducing the Course

Rodents and other wildlife pests continue to threaten agricultural production in many areas even though major changes in their native habitats and natural surroundings have occurred. The control of mice, rabbits, rats, raccoons, squirrels, and similar pests constitutes a major concern of producers--both of crops and of animals. The use of chemicals has resulted in effective means of controlling the damages of these predators. Agricultural chemical technicians can be expected to be familiar with the proper use of these resources in the field of rodent and predator control.

The following suggestions may be useful in arousing a high level of interest at the beginning of this course:

1. From information obtained from workers in industry, business, public service, and education develop a list of skills, abilities, and understanding which technicians need in order to be able to effectively control rodents and other predators. Categorize the entries of your listings under one of the following subheadings:

    a. An overview of man's attempt to control field rodents and especially his use of chemicals in this attempt.

b. Federal, state, and local laws, regulations, and controls which pertain to the use of rodenticides.

c. The recognition and identification of predators commonly encountered and also injury or damage done by such animals.

d. The chemical resources which are available for use to control field rodents and other predators.

e. The principles and concepts which are related to agricultural production and rodent life which are related to the use of rodenticides.

f. The skills, abilities, and understandings needed to plan effective rodent control programs.

g. Pertinent terms, nomenclature, definitions, tables, charts, graphs common to the field and also important computations, calculations, conversions, and measurements performed.

h. The safe handling and applying of rodenticides.

2. Have the students assist in developing a list of factors which tend to complicate the task of controlling field rodents and other predators. Such a list might include:

a. The social and ecological implications of the control problem; i.e., many of these animals are enjoyed by people, furnish sport, as in hunting, and are important in maintaining a proper balance of nature.

b. The immensity of the problem (Starlings in some areas).

c. Toxic materials are not yet available which are effective and selective against a single species under all conditions (other desirable species affected).

d. Many rodents and predators ignore baits, repellents, and other toxic materials.

e. Predatory animals have varying degrees of acceptance and reacceptance of a poison.

f. The development of tolerances to poisons varies greatly among predators.

g. Variable effects due to the seasons, age classes, diets, and sex complicate the problem.

3. Invite a representative of a local pesticides firm to talk to the class and relate his experiences in the field of rodent and other predator control.

Competencies to be Developed

I. To develop an interest in and an understanding and appreciation of man's use of chemicals to attempt to control or eradicate field rodents and other predators which prey upon crops and farm animals.

Teacher Preparation

Subject Matter Content

Note: Inasmuch as the field of rodent and predator control is somewhat more limited than some of the other fields, no introductory course to this field was suggested in the curriculum (as was done for six other major fields). Therefore, the instructor will need to be concerned that he cover in this course not only the subject of the chemical resources available for use in control programs but also the study of rodents and predators themselves.

1. The problem or setting

The damage done by field rodents and other predators to crops in the United States amounts to several million dollars a year. Ground squirrels, tree squirrels, pocket gophers, field mice, kangaroo rats, muskrats, birds, and rabbits are all seeking their needs for successful existence--to obtain enough food, to find adequate shelter, and to escape their enemies. Whenever man's farms and gardens offer food or shelter for rodents, they will become his competitors.

Some rodents carry diseases that may be transmitted to man. Bubonic plague, tularemia, and other serious diseases are transmitted to man either directly or by fleas, ticks, or mites living on rodents.

T. R. Hopkins, in Soap and Chemical Specialties, May, 1965, states that each rat in the U. S. eats over $5.00 worth of food per year, and fouls an equal amount so that it has to be discarded. Assuming that there are approximately 200 million rats (Hopkins' estimate), it can be shown the monetary losses due to rats alone are exceedingly high ranging somewhere between 2.5 - 4.5 billion dollars per year. This is about equal to the output of 200,000 farms in the U. S.

Note: The instructor should secure information from state and county agencies which will treat more specifically the problems caused locally by field rodents and other predators.

2. Possible courses of action to take

a. Means of control

1) Poison baits--use of chemicals

2) Poison gases and dusts--use of chemicals

3) Use of repellents

4) Trapping

5) Shooting

6) Exclusion

7) Encouragement of natural enemies

8) Furnish food and shelter away from crop material

9) By removing or minimizing environmental attractions; i.e., food, water, and shelter

10) By capturing the offenders alive and releasing them away from the problem area

b. Control by means of poison baits (introduce at this point--do not go into detail)

One of the most common means of control is by poison baits. Food that the rodent likes--grains, greens, pieces of vegetables or fruits--is poisoned and scattered broadcast or placed in burrows or other protected spots. Baits should not be scattered on the ground if they will be dangerous to livestock, beneficial wildlife, or human beings.

Control work with poison, even under official agencies, has been criticized because it may kill other animals besides rodents. Hardly any control operation (except selective shooting) is without some possible danger to other forms of wildlife. But careful use of the more conservative methods will keep this danger low.

c. Control by means of poisonous gases and dusts

Several poisonous gases have served to control ground squirrels and, less often, gophers; the most often used is carbon disulfide. The method of application varies with the gas. These gases can be bought in cans or drums. Dusts are spread in order that rodents might contaminate themselves when traversing through them.

d. Examples of control programs (cite local examples if possible)

1) Bubonic plague in California spread from rats to squirrels and other rodents. Thirty-five counties were affected by 1946.

2) Other

3. Major determinants which need to be made in order to develop a chemical control program

   a. Identification of the kind of rodent concerned with

   b. Kind of chemical to use

   c. Time to use chemical

   d. Placement

   e. Amounts needed

   f. Concentration to use

   g. Method of application

   h. Ease of application

   i. Relative safety in using

   j. Cost

   k. Toxicity

4. Problems encountered in using chemicals to control field rodents and other predators

   a. Health and safety hazards inherent in the use of some chemicals

   b. Difficult to secure satisfactory results under many circumstances

   c. Dangers to other animal life

   d. Danger of residues--primary and secondary

5. The rodenticide industry

   a. History and background

      1) Use of vegetable poisons--hyoscyamus, hellebore, henbane, hound's-tongue, hemlock

      2) Limited use of arsenic compounds

      3) Red squill (1718) in France

      4) Phosphorus, barium carbonate of German origin

b. Present status and situation

c. Recent changes and future trends

Suggested Teaching-Learning Activities

1. Have the students bring in labels and used containers of rodenticides. Note the brands, trade names, active ingredient, company and instructions for use.

2. In cooperation with local growers determine the extent field rodents and other predators are a problem in the local area. Examine the control program being followed on several farms and ascertain the approximate values resulting from the use of a control program (or the lack of adopting one).

3. Determine the amounts of various chemicals used annually to control rodents and similar pests at the local, state, and regional levels.

4. Invite a local pest control operator to share his experiences of controlling rodents with the class.

Suggested Instructional Materials and References

Chitty and Southern, Control of Rats and Mice, The Claredon Press, Oxford, England, 1954. 3 volumes.

Storer, Control of Field Rodents nn California Farms, Circular 535, University of California Extension Service, 1965.

Controlling Pocket Gophers and Moles, Leaflet 135, University of California Extension Service, 1961.

II. To develop the ability to use important terms, nomenclature, definitions, tables, charts, and guides which are used in the field and also to develop the ability to perform important computations, conversions, calculations, and measurements which are commonly used by technical workers in the field.

Teacher Preparation

Subject Matter Content

Note: This unit is presented here at an early point in the study guide in order that the instructor may review it and make plans to make use of the data and information provided for herein throughout the remainder of the course. It is not intended that the unit will be taught as a separate competency, as are the other six major units of the course, but that the material provided for here will be integrated as appropriate throughout the rest of the study. The purpose of this section then is to provide for the pulling together in one place a core of information appropriate to the course.

It will be necessary for the instructor to gather information and materials from various sources including the ones recommended in this unit.

Guidelines in the form of an outline for use in summarizing data gathered pertinent to this section are presented.

Data presented in this section of the study guide for the course "the Use of Chemicals as Insecticides" may be useful. Present here those materials and that information needed which has not been presented to students previously.

SECTION ONE - General Information

THE STUDENT WILL NEED TO BE ABLE TO:

1. Make use of words, terms and phrases appropriate to the subject matter of the course. A Glossary of Terms will facilitate this usage.

2. Perform measurements, conversions, computations, and calculations commonly done by technical workers in the field. Tables containing units of measurement and tables of equivalents of units will be useful.

a. Tables of measurement

-- Linear measure - length

-- Square measure - area

-- Cubic measure - volume

-- Liquid measure - capacity

-- Dry measure - capacity

-- Weight measure

-- Temperature measure

-- Time measure

-- Other

b. Tables of convenient equivalents

-- Equivalent volumes - liquid measure

-- Equivalent volumes - dry measure

-- Equivalent weight/volume - liquid

-- Equivalent weight/volume - dry

-- Equivalent lengths

-- Equivalent areas

-- Equivalent weights

-- Equivalent temperatures

-- Equivalent other

SECTION TWO - Information Regarding Agricultural Chemicals

THE STUDENT WILL NEED TO MAKE USE OF:

1. A table which lists the common name, active ingredient, and trade name(s) of chemicals studied in the course.

   Example: Warfarin 3-(alpha-acetonylbenzyl)-4-hydroxycoumarin

   d-Con, Duocide, Rat-gard

2. An alphabetical listing of chemicals commonly used in the field. Information such as the trade name, name of major producer, composition, formulation, and recommended use.

   Example: Antu (DuPont)

   1-(1-Naphthyl) -2-Thiourea; 100% powder, 20% tracking powder, 1-2% baits; recommended use against Norway rats.

3. A listing of chemical materials according to the general use

   Example: <u>Rodenticides</u>

   -- Warfarin

   -- Antu

   -- Raticate

   -- Pival

   -- Gophacide

4. Compatibility charts and tables

   a. Phytotoxicity (with plants)

   b. Chemicals (with other chemical)

   c. Physical (with other chemical)

5. Toxicity tables providing LD and LC values (both oral and dermal, acute and chronic) of chemicals studied in the course.

6. Tolerance limitations imposed by F.D.A. upon residues applicable to the subject matter of the course (i.e., herbicides, fungicides, etc.).

<u>What is one part per million</u>?

Most lay people have no conception of what constitutes one one part per million residue on crops. The following examples may help you make this interpretation for them:

1. One inch is one part per million in 16 miles.
2. A postage stamp is one part per million of the weight of a person.
3. A one gram needle in a one ton hay stack is 1 ppm.
4. One part per million is one minute in two years.
5. Lay your hand on the ground and it covers 5 ppm of an acre.

6. If one pound of a chemical lands on an acre of alfalfa the hay has 500 ppm. One ounce of a chemical would impart 31 ppm.
7. A teaspoon of material on an acre of alfalfa would impart 5 ppm.
8. One teaspoon of DDT drifting onto 5 acres of alfalfa puts 1 ppm in the hay, and the Federal Law says that the hay must contain none.

(Source--Western Crops and Farm Management)

SECTION THREE - Preparation of Chemicals for Use

THE STUDENT WILL NEED TO BE ABLE TO:

1. Determine whether or not materials prepared and commercially packaged can be applied directly from the container.

2. Determine the total amount(s) of active ingredient(s) contained in a chemical mixture. Mixtures may vary according to weight, volume, concentration, and formulation.

3. Make a determination of the amounts, by weight or by volume, of chemical materials of various levels of concentration to use in order to prepare a given quantity of mixture that will meet recommended or specified dosage or concentration levels. (Weights or volumes of solid or liquid chemicals required to prepare a given quantity of material of different dilutions.)

4. Interpret tables and recommendations for "concentrate" spraying.

SECTION FOUR - Preparation Necessary in Order to Secure Specified or Recommended Application Rates

THE STUDENT WILL NEED TO BE ABLE TO:

1. Compute the area of various plots of land. These plots will vary in size, shape, topography, and planting.

   a. Determine acreage of row planting which vary according to spacing.

   b. Determine total acreage of plots.

2. Determine the speed of a vehicle traveling on the land. (In miles per hour and feet per minute.)

3. Three variables affect the application rate of agricultural chemicals secured in the field - the speed of travel, the effective width of the device applying the chemical, and the total material delivered per unit of time. If two of these variables are known, calculate the other in order to secure a specific application rate.

   a. Calibrate sprayers, dusters, or metering devices to secure specific delivery rates.

   b. Compute the length of boom, number of outlets, or width of opening to secure specific widths.

   c. Calibrate ground speed to secure specific rate of forward travel.

4. Use tables of "Rate of Equivalents"

   Example: 1 ounce per square foot = 2722.5 pounds per acre

5. Calculate the quantity of spray per length of row (on various spacings) which will be equivalent to a specific application per acre.

6. Determine the gallons per acre required to spray orchards of different planting distances.

7. Consider the effect of particle size on drift and deposit. (Prepare spray drift and deposit table.)

SECTION FIVE - Information Relative to Diagnosis and Prescription

THE STUDENT WILL NEED TO MAKE USE OF:

1. Tables, charts, and guides which summarize situations encountered in agricultural production in which the use of chemicals is appropriate. Materials to use and methods of application are suggested.

Examples of form used:

Plant Soil or Habitat	Pest, Disease or Condition	Causative Agent or Factor	When to Treat	What Material to Use
Storage bins	Rodent	Rats	Upon infestation	Pival

Active Ingredient in Bait	Formulation	Amount Concentration Req'd	Method of Application	Remarks
.5% powder 2-Pivalyl-1, 3-indandione	Powder	Cereal bait - .025% Water bait - .005-.006%	Multiple feeding in bait stations required	Very slight chance of secondary poisoning

2. Graphs, charts, tables and other illustrative materials available and supportive of the unit under consideration.

Examples:

a. Graphical relationships

-- time versus residue levels

-- rates of application versus levels of effectiveness

-- levels of concentration versus levels of effectiveness

-- stage of development or growth versus effectiveness of chemical control, etc.

SECTION SIX - Sources of Information

1. An excellent review of the properties of the chemicals used in rodent control is presented in Chapter II of Control of Rats and Mice, Volume I, by Chitty and Southern.

2. Baits and formulas as well as recommendations for control are listed in "The North Carolina Pesticide Manual."

3. Thompson, W. T., Agricultural Chemicals, Book III, The Simmons Publishing Co., Davis, Calif., 1965. A manual which lists widely used chemicals for rodent control.

III. To develop the ability to recognize and identify field rodents and similar pests which attack agricultural crops.

Teacher Preparation

Subject Matter Content

Note: Because of the great variability found in the kinds of rodents in different parts of the nation, the instructor will need to gather information relative to important species of the local area. The following outline may be useful as a guide.

1. Groups of rodents and other predators
   a. Ground and tree squirrels
   b. Pocket gophers and moles
   c. Miscellaneous rodents and rabbits (mice, rats, etc.)
   d. Other predators (birds, possums, raccoons, fox, etc.)
2. Characteristics and attributes of each of the groups
   a. Names
      1) Common
      2) Species
      3) Sub-species
   b. Habitat and general considerations
      1) Favored environment
      2) General kinds of habitats
      3) Location
      4) Characteristics of burrows, nests, etc.
      5) General attitude toward the environment and any changes in it
      6) Fixing of habit rhythms
      7) Hibernation/estivation

c. Feeding

1) Rates (number of times and rapidity)

2) Behavior

3) Reactions to poisons

4) Food preferences

d. Breeding

1) Season of

2) Rates

3) Pregnancy length

4) Frequency of families

5) Age

e. Population

1) Dynamics

2) Sex ratio

3) Family size

4) Structure

5) Density of numbers

6) Movements

7) Natural mortality rates

f. Damage or danger

1) Kinds

2) Extent of damage usually sustained

3) Typical symptoms

IV. To become knowledgeable at the technical level concerning various chemicals used as rodenticides.

Teacher Preparation

Subject Matter Content

1. Common types of rodenticides

   a. Classified according to method of application

      1) Poisonous bait

         a) Food preferred by predators are prepared, either in wet or dry form, and then are mixed with a suitable poison. Rolled oats or other cereals, bread crumbs, stale bread, mineral oil, corn oil, molasses, peanut butter, tomatoe puree, canned or raw meat or fish, fish meal, fresh or cooked vegetables, and fresh fruits are materials which have been used.

      2) Poisonous gases

         a) Toxic gases under pressure are used to control rodents in burrows and other enclosures of difficult access.

      3) Poisonous dusts

         a) Certain toxic dusts, exposed where rodents travel and where human food will not be contaminated, are useful to control certain kinds of rodents.

      4) Repellents

   b. Classified according to chemical nature

      1) Organic materials

      2) Inorganic materials

2. Study of the chemicals used as rodenticides

   a. Before presentation is made of the various chemicals which are commonly used as rodenticides, the following outline is included for the instructors consideration. The use of this guide may help to facilitate the detailed study of these chemicals.

   b. Guide for the study of agricultural chemicals

Note: The instructor will determine which chemicals are to be studied in depth. This selection of course depends upon the requirements of local areas and situations. Other items should be added to the guide as appropriate.

1) Chemical name (active ingredient)

2) Empirical formula

3) Chemical structure

4) Common name

5) Trade name(s) and major producer(s)

6) Melting point

7) Vapor pressure

8) Solubilities

9) Odor

10) Color

11) Color additives

12) Density

13) Physical state (liquid, solid, gas)

14) Corrosive action

15) Flammability

16) Stability

17) Compatibility

18) Suitable diluents

19) Concentrations

20) Purities/grades

21) Mixtures available

22) Industrial prep[redacted]

23) Formulations for use/additives used

24) Symptoms and post-mortem findings

25) Analytical methods

26) Analysis of mixtures

27) Phytotoxicity/Bioassy

28) Toxicity (LD_{50}, LC, ppm oral, dermal, acute, chronic)

29) Relationship between particle size and toxicity

30) Special hazards and dangers to men, domestic, or wild animals

31) Residues likely, tolerance limitation

32) Synergists possible for use

33) Intended general use (insecticide, fertilizer, nematocides, etc.)

34) Intended specific use

35) Antidotes and first aid

36) Factors which limit the effectiveness of the chemical (such as temperature, sunlight, water, etc.)

c. Chemicals used as rodenticides

1) Poisons used in baits

a) Red squill

b) Arsenious oxide

c) Zinc phosphide

d) Phosphorus

e) Thallium sulphate

f) Strychnine

g) Alpha-naphthylthiourea (antu)

h) Sodium fluoracetate (1080)

i) Sodium arsenite

j) Barium carbonate

k) Fluoroacetamide (1081)

l) Anticoagulants

-- Warfarin

-- Pival

-- Fumarin (Caumafuryl)

-- Diphacin (Diphacinone)

-- Caumachlor

m) Viruses

Certain bacterial cultures have long been sold and used (mainly in Europe) for rat control on the assumption that spreading a disease will be effective. The bacteria used belong to the food-poisoning group (Salmonella) and may contaminate human food. The sale of these cultures is prohibited in many states.

2) Poisons used as gases

a) Calcium cyanide (cyanogas)

b) Carbon disulfide

c) Carbon dioxide

d) Carbon monoxide

e) Methyl bromide

f) Chloropicrin

3) Poisons used as dusts

a) Sodium fluosilicate

b) DDT

c) Antu (alpha-naphthylthiourea)

4) Repellents

a) Lye

b) Paradichlorobenzene "PDB"

c) Naphthalene

d) Sulfurized linseed oil

Suggested Teaching-Learning Activities

1. Prepare a kit of samples representative of the different rodenticides studied in this unit. Classify according to the outline presented.

2. Have the class participate in the research needed for the preparation of a comprehensive study guide on rodenticides.

3. Design experimentations and conduct demonstrations to show characteristics and attributes of the chemicals studied in this unit.

Suggested Instructional Materials and References

Laboratory quantities of the various chemicals considered in this unit.

Handbooks of chemistry.

Chitty and Southern, Control of Rats and Mice, Vol. I, Oxford University Press, England, 1954, Chap. II.

Storer, Control of Field Rodents on California Farms, Circular 535, University of California Experimental Station, 1965.

Farm Chemiaals Handbook, Meister Publishing Co., Willoughty, Ohio, 1966.

V. To gain a knowledge and understanding of the principles and concepts underlying the use of chemicals needed to control field rodents and similar predators.

Teacher Preparation

Subject Matter Content

In addition to having a knowledge of the technical aspects of the chemicals used in rodenticides, it is also necessary for the technician to understand the basis upon which these chemical resources are most effective in the field. Further considerations regarding the chemicals themselves and also the animals for which they are intended are worthy of further study.

1. Rodenticides are effective to the extent they are used according to acceptable and recommended practices. The efficiency of a poison against rodents varies according to a number of variables (other than its inherent toxicity).

    a. Age, sex, and weight of animal

    b. Resistance to poison

    c. Amount and types of food in the animal's stomach

    d. Variations in the baiting system; the gassing or dusting system

    e. The bate base

    f. The concentration of the poison

    g. The amount of previous poisoning

    h. The general health of the predator

    i. The environmental conditions

        1) The availability of water

        2) Weather

        3) Influences of other enemies

        4) Differences in special habitats

2. Direct poisoning - Direct poisoning is poisoning without practicing prebaiting.

    a. Tests conducted by many researchers present strong empirical evidence against the efficiency of direct

poisoning of a number of species. However, improvement in base materials, time, and labor savings as well as elimination of wasted bait make this method increasingly competitive.

3. Prebaiting

a. The chief advantage of prebaiting is in overcoming the predators' suspicion of an unfamiliar food supply. In regard to prebaiting rats, Storer cites the following:

> Prebaiting. For many years it has been common practice simply to put down baits in places frequented by rats, leave them for one or more nights, and then remove the uneaten baits. Some rats were killed, but results were usually unsatisfactory. A recent major improvement is the use of prebaiting (Bartlett, et al., 1946). Small piles of clean unpoisoned baits are placed at selected sites or in special bait containers for several nights, the supply being replenished whenever rats take the material. The prebait is then replaced by poisoned food of the same kind, which is left 1 to 3 nights, and then the remainder removed.
>
> Prebaiting takes account of an important feature in rat behavior--a suspicious fear and avoidance of new objects, even a new food. If clean prebait is offered, they will, after one or more nights, overcome their fear and usually accept the new food. Also, when sites are prebaited for several nights in succession, increasing numbers of rats will come to feed at these places. Then when poisoned bait is substituted, a larger number will be killed.
>
> A convenient program is to prebait on the first, third, and fifth days, replace with poisoned bait on the sixth day, and remove all remaining poison and dead rats on the eighth day. If acceptance of the prebait is poor, the prebaiting period should be extended for several more days. The largest take of poisoned bait will be on the first night it is exposed; a little may be taken the second night, but practically none thereafter.
>
> Prebaiting may provide a crude method of estimating the number of rats using bait stations. A given weight of prebait--say 2 ounces, which may be measured by bulk with a suitable spoon--is put out at each station. On succeeding days, if much is eaten, the station is refilled, doubling the amount each time (4, 8, 16 ounces, etc.), and this practice is continued until the amount taken "levels off," when a maximum number of rats will be eating at the station.

Assuming each animal eats about 1 ounce (25 to 30 grams), one may estimate the number of rats. Then after poisoned bait has been substituted, a guess as to the number killed can be made, on the basis of 1/3 ounce (10 grams) per rat, since the animals eat a smaller amount of poisoned food. A week or two after poisoning, an estimate of those remaining can be made by using a new bait (unpoisoned) and determining the amount removed.

4. Placement of baits

The effectiveness of control programs vary according to the nearness which either prebait or poisoned bait is placed to the natural habitat of the predator.

5. Changing of baits

Survivors become and remain bait-shy and a most frequent cause of failure to achieve or maintain effective rodent control is the incorrect use of poison in subsequent treatments. Base and poison should both be changed in successive treatments.

6. Formulations of poisons used

a. Red squill

A large onion-like bulb of the Mediterranean region, when sliced, dried and powdered serves as poison for rats and mice. Different batches of red squill vary widely in toxicity. Of all stomach poisons it is safest for use by the general public but not always efficient. Cats, dogs, hogs, chickens, and pigeons usually will not eat squill baits. They vomit if they do (but rats cannot). The bait mixture used is (by weight) one part red squill (powdered) and bait-9 parts.

b. Arsenic (As_2O_3)

The heavy white powder commonly called arsenic (also known as arsenic trioxide, arsenious acid) has often been used for rodent control. It is now less in favor in the United States than in England and elsewhere. The arsenic must be of very fine particle size (6 to 9 microns) for good results, since the larger particles are less toxic. It should be well refined because impurities make arsenic less acceptable. The laws of some states and countries require that arsenic be colored blue or green to distinguish it from flour, soda, and other harmless or edible white powders, but this does not affect its toxicity.

Bait	90 parts by weight
Arsenic trioxide	10 parts by weight

Arsenic has been used with various dry and moist baits. In preparing and distributing baits, workers should be careful to keep arsenic off the skin, which is irritated by the chemical.

c. Zinc Phosphide

This chemical (Zn_3P_2) is a heavy dark gray powder with a faint odor of phosphorus resulting from the slow release of phosphine (PH_3). Both the powder and gas are serious poisons. Zinc phosphide should be weighed, mixed, and handled only out-of-doors or in a well-ventilated room and workers should wear gloves of leather or rubber when mixing or distributing poison baits.

Bait	96 to 100 parts by weight
Zinc phosphide, powdered	1 part by weight

Corn oil, mineral oil, or glycerin, at 12 to 24 fluid ounces per 100 pounds of bait, is often added to any dry cereal to make the poison adhere. The bait and poison are first mixed dry until the zinc phosphide becomes an evenly distributed coating. Then the oil, well warmed, is added slowly and the mixture is stirred again. Baits may be cereal or bread crumbs alone or may include some fresh fish, horse meat, or hamburger. Ground apple or carrot are sometimes used. Stale bread, without an oil, but mixed with an equal amount of water, has been used with 2 1/2 to 5 per cent zinc phosphide in England.

d. Antu

The chemical known as antu (alphanapthyl-thiourea) is of use in control of Norway rats. It is a fine bluish-gray powder that keeps well when dry and is insoluble in water. It may be mixed with wet or dry foods (cereals, bread, etc.) and adheres well when dusted from a sifter on cut moist baits of apple, sweet potato, cantaloupe, or watermelon and on ground meat, ground fish, or chicken heads.

Bait	100 parts by weight
Antu	2 or 3 parts by weight

This substance is quite poisonous to dogs, cats, and pigs; when used care is needed to keep these animals from the poisoned baits. Antu will not seriously poison poultry or man. For rodents other than the Norway rat, it is far less toxic and other poisons should be used for control of those animals (Richter, 1945; Ward, 1946).

e. Barium Carbonate

Formerly this heavy, fine white powder was used commonly but it has been largely discarded in favor of more dependable poisons. While cheap, it is not always easy to buy.

Bait	4 parts by weight
Barium carbonate	1 part by weight

Corn meal, rolled oats, bread, and ground meat or fish have served as baits. Dry materials are first mixed with the barium carbonate, then moistened. Bread baits may be moistened with milk; "sloppy" baits may be more effective in hot weather. Fresh foods should have the dry barium carbonate sifted over them and should be stirred until evenly coated or mixed with the poison.

f. Warfarin

New in materials for rodent control is warfarin (Compound 42) which is licensed for manufacture and sale by the Wisconsin Alumni Research Foundation. Unlike the usual poisons, this substance produces fatal internal bleeding (hemorrhage) when eaten in sufficient amount over several days. Additional differences are that rats and other rodents take baits containing warfarin without hesitation and will continue to do so until death overcomes them after several days. No prebaiting is necessary. (Hayes and Gaines, 1950.)

This substance is marketed under various trade names (all packages show the active ingredient as warfarin). As offered for sale warfarin is available in two forms. One is a 1:200 (5%) mixture with flour or other powder that is to be combined with bait at 1:19 ratio by weight so the final mixture contains warfarin in a strength of 1:4000 (about 100 milligrams per pound). With dry baits (rolled oats, etc.) mineral oil at one quart per 15 or 20 pounds of bait may be added so that the powder will adhere and be spread uniformly. The other form is ready-to-use bait with warfarin in 1:4000 ratio (0.025 per cent).

The final mixture can be exposed like other baits in small piles or in bait boxes. As taken by rats the supply must be replenished so that it will be available for the animals to eat as often as they desire. Bait spots should be so maintained for 10 days to 2 weeks or longer. In trials with warfarin it is common experience that after rats begin feeding there is a large initial take of bait for several days, then lesser amounts are removed as rats die off, and finally small quantities are eaten irregularly as rats from outside enter the area baited.

The only serious hazard in using warfarin is to domestic cats and dogs (two ounces of bait per day for 3 or 4 days would probably kill an 11 pound dog); like rats, these pets are killed by feeding on the baits for several days. A single meal, even of some size, is usually not fatal. Cats may die after feeding several days on poisoned rats.

g. Yellow Phosphorus

The basis of many commercial poisons is yellow phosphorus which is often sold in a syrup to be spread on baits of bread and other foods. Some of these preparations are fairly effective.

Phosphorus has a distinctive, garlic-like odor, and is luminous in the dark, but these features do not prevent rats from eating phosphorus baits. There probably is a fire hazard from phosphorus only when the particles are larger than of microscopic (colloidal) size.

h. Thallium Sulfate (Thallous sulfate, Tl_2SO_4) and "1080" (Sodium fluoroacetate)

Two other rodent poisons are not available to the general public in many states because of the great hazards they involve. Baits poisoned with these chemicals have no distinctive appearance, taste, or smell. Both are toxic to rodents, other wild animals, domestic livestock, and man.

Thallium sulfate (thallous sulfate Tl_2SO_4) is a "heavy metal" poison obtained from smelters. It has been used by government agencies for control of both rats and field rodents. Thallium poisoned grain has several times improperly come into the hands of persons who, not knowing it was poisoned, used it for food.

Since 1945, a new wartime discovery, "1080" (sodium fluoroacetate), has been used by military and government agencies for rodent control (Kalmbach, 1945; Ward, 1946). It is very effective, but extremely dangerous. Pet dogs and cats may be poisoned by eating rats or mice killed by "1080." Several human deaths, particularly among children, have occurred with "1080" in rat control. Like thallium, its sale is restricted by law in many states.

These poisons can only be used by properly trained persons and in places where there is little chance of secondary poisoning.

There is no certain antidote for either of these poisons. Thallium is a slow-acting poison, but "1080" works so rapidly that it has been impossible to save experimentally poisoned animals even with prompt first aid under the best of laboratory conditions.

7. Poisonous gases

a. Calcium Cyanide

This compound, $Ca(CN)_2$, is the most common material used for gassing. In the presence of moisture (water in the air or soil of rat burrows), this chemical forms hydrocyanic acid gas (HCN). Both calcium cyanide and the gas are deadly poisons for animals, insects, and man. In parts of the arid West and Southwest during the dry season there may not be enough moisture for successful use of cyanide, and cracks in the ground may permit quick escape of the gas, which is lighter than air.

Calcium cyanide is available both as a dust (Cyanodust A) and in granular form (G Fumigant). The dust is applied with a special pump. Air is forced through a glass jar which contains the powder, and the dust-laden air passes through a hose into the burrow. The tip of the hose is placed 10 to 12 inches inside the burrow, the entrance is closed with earth, and several strokes are made with the pump. If dust is seen coming out of hidden "bolt holes" or through cracks in the ground, such openings should be covered with earth. The dust produces a high concentration of gas in the burrow, but only for a short time.

Corn cribs may be temporarily rid of rats by use of a dust pump. There is no danger in using corn from fumigated cribs after several days of damp air, since the poisonous gas is generated rather quickly and the residue is only lime.

When using granular cyanide, place 1 tablespoon (one ounce) of the material 6 to 8 inches inside the burrow with a long-handled spoon, and block the entrance tightly, taking care that the cyanide is not covered. If there is moisture within the burrow, a strong concentration of cyanide gas will develop just inside the blocked entrance, where it will kill any rat trying to dig out. In damp weather the cyanide may be placed during the afternoon. When the temperature is low, the material should be put into burrows during the morning to give time for the gas to form. This method is not effective on garbage dumps, under piles of trash, or in places where the ground is cracked, as the gas will leak away too rapidly.

Cyanide readily dissolves in water; it can be used when the air is damp, but not during a rain or when the ground is wet. The supply can should be covered tightly except when cyanide is being removed. The chemical should always be kept off the operator's hands and clothing.

b. Carbon disulfide (CS_2)

Carbon disulfide applied with a pump or on waste balls, as for control of ground squirrels, can be used against rats. Fluid carbon disulfide burns readily, and the vapor is highly explosive. It should not be used where there is any fire hazard from open flames, cigarettes, electric sparks, or other sources.

c. Methyl bromide (CH_3Br)

Methyl bromide is a highly volatile fumigant occasionally used for burrows, especially where killing fleas for disease prevention is necessary, but it requires special equipment for use.

d. Carbon monoxide (CO)

Carbon monoxide from an automobile exhaust may be forced through a hose into rat burrows. The pressure from the engine drives the gas into all parts of a burrow. Unlike some other gases, carbon monoxide will remain in a burrow for a considerable time, not being absorbed in the soil or soil water; hence, it has a long period of effectiveness. This gas may be used for burrows under cement-floored farm buildings where cyanide would be dangerous to livestock.

8. Poisonous Dusts

a. Sodium fluosilicate (Na_2SiF_6)

If sodium fluosilicate is spread on floors where rats and mice run, some of the dust gets on their hair and feet, proves irritating, and is licked off and swallowed (Mackie, et al., 1934). The rodents die in 3 to 6 days. This chemical contains fluorine and must not be used where it might contaminate food. The dust should not be stirred up; and under no circumstances should kernels of cereals on floors dusted with fluosilicate be swept up and used as food for man or animals.

In some places sodium fluosilicate may be put down in a narrow strip on the floor close to the walls in a room or building. Then boards may be leaned along the floor and against the wall to prevent the dust from being scattered to nearby objects. Rats and mice usually run along the bases of walls, and tend to go beneath boards so placed.

b. Antu

Antu, up to 20 per cent, when mixed in flour, pyrophyllite, or talc, may be dusted heavily (1/8 inch or thicker) on rat runs and entrances to burrows for

control of Norway rats. It has little value for roof or black rats. This is not a major means of control, but has been used to kill a few rats that escape poison, traps, or gas.

c. DDT

In areas where murine typhus is a hazard, DDT dust (5% to 10%) is placed on runways to catch on the feet and fur of passing rats and kill many of their fleas. When the number of fleas, which carry endemic typhus to man, is reduced, there is less danger of spreading the disease when the rats are killed off.

Heavy dusting with DDT is reported to reduce or eliminate house mice in places where this material can be used with safety. It is less effective for rats.

Any of these dusts can be applied with a sifter can. When much dusting is to be done, however, it is helpful to have a large (1 gallon) can with fly screen soldered on one end and a carrying handle on the side. For dusting rat runs on beams and pipes, a small sifter can be fastened at right angles to the end of a 3- or 4-foot stick is convenient.

Suggested Teaching-Learning Activities

1. Prepare various kinds of formulations of rodenticides for use.

2. With laboratory animals, administer various preparations of rodenticides and study the results. Attempt to ascertain the affects of variables other than the toxicity of the chemical used in the pesticide on the effectiveness of the material used.

Suggested Instructional Materials and References

Materials required as base ingredients for baits.

Toxicant materials used in the preparation of the pesticide material to be prepared.

Chitty and Southern, Control of Rats and Mice, Vol. I, Oxford University Press, England, 1954, Chap. II.

VI. To acquire the knowledge and skills needed to handle, transport, store, and use chemicals to prevent, control, or eradicate field rodents and similar predators lawfully and safely.

Teacher Preparation

Subject Matter Content

1. Planning a program of predator control through the use of chemicals and the subsequent implementation of such a program makes use of knowledge, skills, abilities, and understanding gained and developed during this and related courses.

A program of rodent and predator control is not based entirely on one kind of approach. Chemical methods are generally used in conjunction with other kinds of control measures. The planning proposed in this unit presumes the desirability of including other kinds of control, but the focus is upon the use of chemicals.

Guidelines for program planning are proposed. The instructor will need to modify and adapt to fit local circumstances.

a. Guide for planning a rodent and predator control program

1) Determine what the situation is at present and what it is apt to be if pesticides are not used

a) What is the threat of animal infestation

b) What damage is likely to result

c) What danger is posed

d) What risk is involved

e) What degree of control can be expected

f) What are the alternatives within the chemicals field

2) Establish goals and objectives

a) Establish what is desired, what is to be attempted

-- Is it possible, attainable

-- Is it challenging, worthwhile

-- Is it measureable, what tools of measurement are to be used, how will we know of our progress.

b) Spell out goals and objectives in terms of:

-- The crop or crop product under threat

-- The predator(s)

-- The use of necessary inputs

-- The exercise of control over other variables

3) Spell out ways and means to accomplish goals and objectives - devise a plan of action

a) Establish priorities and allocate resources

-- Determine what the operational framework is

-- Spell out limitations

-- Ascertain the specific use to be made of rodenticides

-- Make a selection of the materials to be used

-- Plan for the use of the chemical

-- Determine the form to be used

-- Determine if prebait will be used

-- Ascertain the appropriate time which application will be made

-- Select the method of application

-- Plan for the proper formulation and preparation of the materials for use.

-- Detail the proper placement or application to be made

-- Plan an evaluation procedure to examine the results secured

2. City ordinances and state laws in many states make the owner or occupant of any premises responsible for keeping down rodents. Failure to control them is a misdemeanor that may result in court action.

Building codes of many communities prescribe means to ratproof new or old structures.

Exclusion and sanitation are among the surest defenses against predators; however, other control measures are often necessary. Regardless of the control used, it must be continuous and over a large area if it is to be effective. Most control poisons and gases used to control predators are dangerous to man and livestock, therefore must be used carefully.

3. Poisons and poison baits to be offered for sale in many states must first be submitted to the State Department of Agriculture. Only those which are satisfactory to this agency are offered for sale. In addition, poisons and poisoned baits sold in interstate commerce must also meet the requirements of the Federal Insecticide, Fungicide, and Rodenticide Act of June, 1947. (See the unit presented under this heading and included in the study guide for the course "The Use of Chemicals as Insecticides." Provisions of the federal acts are reviewed in that unit.)

4. General Precautions with Poisons

   a. All of the substances used for poisoning field rodents are dangerous to human beings and to domestic animals. They should therefore be handled, stored, and labeled with great care using the following precautions:

      1) Label all containers "POISON" and keep them locked up and out of reach of children, irresponsible adults, pets and livestock.

      2) Wear an approved mask when mixing powdered or volatile poisons. If working outdoors, do not let the dust drift into watering troughs, irrigation ditches, or food-storage areas.

      3) Mix poison baits, particularly those containing zinc phosphide, out of doors or in a well-ventilated building where there will be less hazard to the operator. Never mix poison in a room where animal or human food is prepared or stored.

      4) A metal-topped table, or one that can be thoroughly washed, should be used for mixing. If necessary to use a wooden table, cover it with wrapping paper, oil cloth, or similar material which can be burned after the mixing operation is completed.

      5) Wear rubber gloves when mixing and distributing poison baits, particularly those containing zinc phosphide. Burn gloves after using or wash them with detergent at some place where the wash water can drain onto soil that can be spaded in. Do not put gloves into garbage for disposal.

6) Wash hands carefully after mixing or handling baits, even though gloves have been worn.

7) Wash utensils thoroughly after mixing baits and pour out the rinse water where it will not be a hazard to people or animals. Utensils employed for mixing poisoned baits must not be used for any other purpose.

8) Always handle poisonous gases out of doors. Do not breathe the fumes. Stand up-wind when using or placing the material in burrows.

9) Store carbon disulfide in tightly-stoppered cans or drums in a cool dry place, out of doors or in a separate building, away from all fire, sparks, and matches. It is a dangerous gas and highly explosive. The drums should be grounded with a wire when filling cans or pump.

10) HANDLE POISONS AS THOUGH YOUR LIFE DEPENDS ON IT. IT DOES!

b. The minimum lethal dosage of strychnine for a human being is considered to be about 0.5 grain or 35 milligrams--equivalent to about 250 kernels of strychnine-coated grain. About 5 ounces of zinc phosphide bait may be fatal for a human being. Carbon disulfide is lethal in a concentration of about 1 part in 1,000 parts of air with 30 minutes exposure.

Antidotes for the different poisons vary, and some may be uncertain or not wholly effective in their action. In a case of accidental poisoning, it is imperative that a physician be called immediately for most effective use of antidotes.

Suggested Teaching-Learning Activities

1. Using simulated poison bait materials (dnn't tell students they are harmless until exercise is completed), have students prepare baits, make applications, and clean up afterwards.

2. Demonstrate proper placement of chemical baits or other rodenticides in a cooperating farmer's field or building.

Suggested Instructional Materials and References

Materials required for rodent control.

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INSTRUCTOR NOTE: As soon as you have completed teaching each module, please record your reaction on this form and return to the above address.

1. Instructor's Name_____

2. Name of school_____State_____

3. Course outline used: _____Agriculture Supply--Sales and Service Occupations
_____Ornamental Horticulture--Service Occupations
_____Agricultural Machinery--Service Occupations

4. Name of module evaluated in this report_____

5. To what group (age and/or class description) was this material presented?____
_____

6. How many students:
a) Were enrolled in class (total) _____
b) Participated in studying this module _____
c) Participated in a related occupational work experience program while you taught this module _____

7. Actual time spent teaching module:

		Recommended time if you were to teach the module again:
_____hours	Classroom Instruction	_____hours
_____hours	Laboratory Experience	_____hours
_____hours	Occupational Experience (Average time for each student participating)	_____hours
_____hours	Total time	_____hours

(RESPOND TO THE FOLLOWING STATEMENTS WITH A CHECK (✓) ALONG THE LINE TO INDICATE YOUR BEST ESTIMATE.)

	VERY APPROPRIATE	NOT APPROPRIATE
8. The suggested time allotments given with this module were:		
9. The suggestions for introducing this module were:		
10. The suggested competencies to be developed were:		
11. For your particular class situation, the level of subject matter content was:		
12. The Suggested Teaching-Learning Activities were:		
13. The Suggested Instructional Materials and References were:		
14. The Suggested Occupational Experiences were:		

(OVER)

15. Was the subject matter content sufficiently detailed to enable you to develop the desired degree of competency in the student? Yes_____No_____
Comments:

16. Was the subject matter content directly related to the type of occupational experience the student received? Yes_____No_____
Comments:

17. List any subject matter items which should be added or deleted:

18. List any additional instructional materials and references which you used or think appropriate:

19. List any additional Teaching-Learning Activities which you feel were particularly successful:

20. List any additional Occupational Work Experiences you used or feel appropriate:

21. What do you see as the major strength of this module?

22. What do you see as the major weakness of this module?

23. Other comments concerning this module:

_____ _____
(Date) (Instructor's Signature)

_____
(School Address)